Appendix I – Transportation Documentation

- WSDOT Property Acquisition Meeting. Meeting Minutes. March 31, 2006. WSDOT Urban Corridor Office.
- Impacts of I-5/SR 509 Project on the Bow Lake Transfer Station. King County Solid Waste Division (2006).
- Local Street Traffic Impact Evaluation for King County Transfer Stations. King County Solid Waste Division (2005).
- Summary of Preliminary Transportation Assessment – Bow Lake Transfer Station. King county Solid Waste Division (2004).

MEETING MINUTES
Bow Lake Transfer Station
Facility Master Plan Update and Implementation
Phase 1 – FMP Update
WSDOT Property Acquisition Meeting
March 31, 2006
WSDOT Urban Corridors Office

Attendees:

Susan Everett, Engineering Manager WSDOT
Paul Johnson, Project Engineer, WSDOT
Andrew Lau, Property Manager, WSDOT
Neil Fujii, Managing Engineer, King Co.
Dwin Ugwoaba, Project Manager King Co.
Tim Hedges, Senior Transportation Engineer, The Transpo Group
Harold McNelly, Facilities Management, King Co.
Lillian Holley, Facilities Management, King Co.
Karl Hufnagel, Project Manager, R. W. Beck

1. The purpose of the meeting was to review preliminary layout prepared for WSDOT for future possible north bound I-5 on ramp improvements at the South 188th Street, and to identify whether there would be any conflicts stemming from the County's proposed Bow Lake Transfer Station redevelopment project that would impact WSDOT's future improvement plans.

2. Neil and Karl first reviewed the latest project site plan layout and site cross sections (attached). WSDOT staff noted that the north access road no longer suggests a future northward extension, which is consistent with WSDOT's preferences as expressed at a previous meeting. Karl made the point that the site plan does not accurately reflect where retaining walls may be needed along the west side of the proposed north access road, whereas the cross sections (B and C) do indicate that the intention is to have retaining walls along a major part of this road so as not to infringe on WSDOT property. Average daily and peak daily and hourly customer traffic numbers at the transfer station in 2030 were briefly reviewed.

3. Susan said that King County should keep in mind that retaining walls adjoining I-5 will need to be designed to accommodate appropriate loading from future vehicular traffic.

4. Susan indicated that WSDOT would be amenable to granting a construction easement so that earth embankment on the WSDOT side of the retaining walls discussed in 2 could be removed down to freeway elevation, thereby reducing the overall height of the wall required.

5. Tim Hedges reviewed the preliminary layout drawing of the on ramp improvements. During the ensuing discussion, WSDOT staff indicated flexibility in the alignment of the ramp lanes such that the apparent conflict or near conflict in the vicinity of the existing cell phone towers might be avoided. It was suggested that the stop bar and control point be moved further north to achieve 1000 feet of queuing length if possible. Paul and Susan discussed the possibility of moving the off and on ramp intersection point further west to enlarge the left turn pocket for customers entering the transfer station.

6. Based on the preliminary layout, WSDOT staff indicated that there appeared to be adequate room for WSDOT's planned future improvements, including an additional travel lane on the main line, and the County's project. WSDOT staff indicated that their favorable recommendation on the sale of the property to WSDOT headquarters would be conditioned on maintaining limited access on the proposed north access road.

7. Susan discussed the possibility of impact fees or payment of mitigation costs based on the results of the traffic study that will accompany the SEPA environmental review process.

8. It was agreed that the next step was for the County to submit an updated drawing (pdf) showing the latest proposed site arrangement coupled with the on ramp improvements revised as discussed above.

Attachments

Distribution: Attendees, Greg Harry, KPG, Ian Sutton, R. W. Beck, Steve Bingham, Adolfson

File: 11-00839-10000/2003

The Transpo Group

MEMORANDUM

Date: February 7, 2006 **TG:** 02150.00

To:

From:

cc:

Subject: Impacts of I 5/SR 509 Project on the Bow Lake Transfer Station

This memorandum discusses the I-5/SR 509 Freight and Congestion Relief project in southwest King County and the impacts that may be incurred near the Bow Lake Transfer Station.

Project Description/Need

The I-5/SR 509 Freight and Congestion Relief project will extend SR 509 from its existing termination point at South 188th Street /12th Place South to a connection with Interstate 5 at South 200th Street. In addition to this connection I-5 south will be widened from Military Road to South 320th Street. This connection will serve current and future transportation needs by enhancing the southern access to Sea-Tac Airport.

Existing/Future Conditions

Currently SR 509 terminates at South 188th Street / 12th Place South and does not connect to the regional transportation highway system, causing congestion along 188th Street, SR 99, and I-5 during peak hours. Increases in future traffic volumes caused by economic growth and increased airport activity will result in continued congestion along 188th Street, SR 99, and I-5.

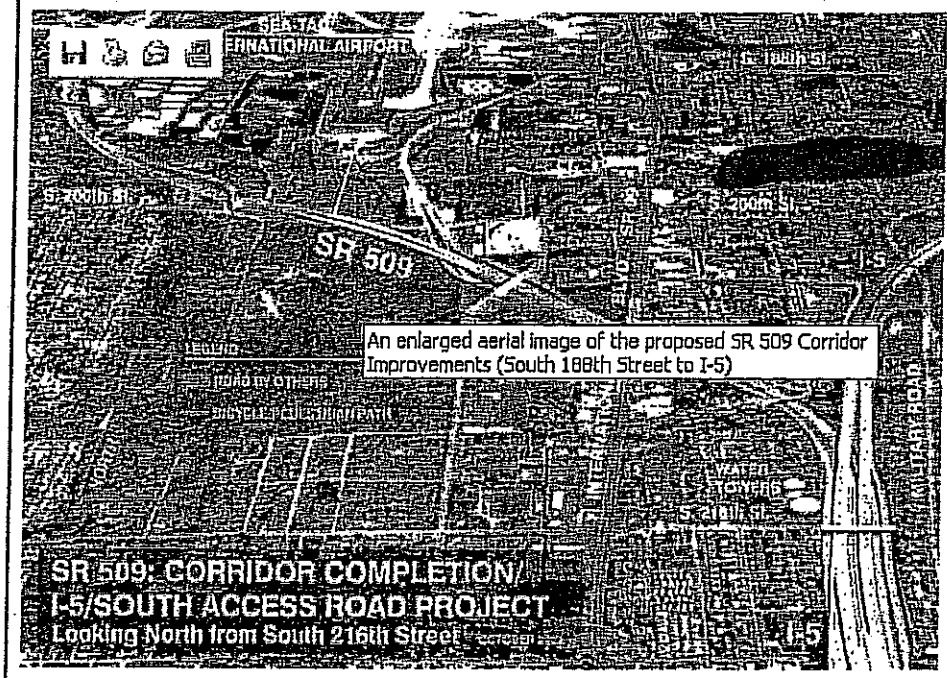
Future Circulation With-Project

The implementation of the SR 509 extension to I-5 will provide a direct connection to Sea-Tac Airport and shift traffic from existing travel routes enabling better circulation on SR 99, I-5, and 188th Street corridor. The addition of travel lanes along I-5 will also reduce congestion in the area. Motorists currently traveling on I-5 to access SR 509 via South 188th Street will be removed from this interchange and shifted to the new connection provided at South 200th Street

Impacts to Bow Lake Transfer Station

The SR 509 project should have little to no impacts on the area near the Bow Lake Transfer Station. Physically no changes to the interchange will affect right-of-way or access to Bow Lake Transfer Station. Additional lanes added to Interstate 5 will occur south of the site. Traffic volumes adjacent to the transfer station currently travel to/from the east via Orillia Road. Future circulation with the implementation of the SR 509 extension will not re-route the majority of these travelers. 2020 PM

peak hour level of service on Orillia Road is not expected to change with or without the project.



An enlarged aerial image of the proposed SR 509 Corridor Improvements (South 188th Street to I-5)

An enlarged aerial image of the proposed SR 509 Corridor Improvements (South 188th

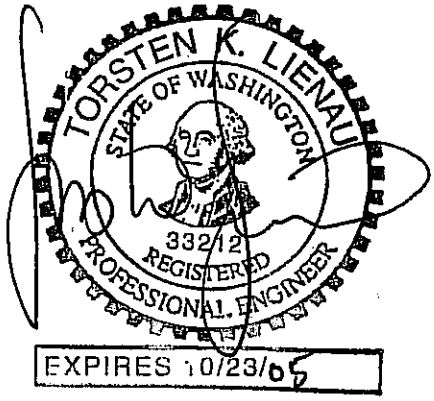
Internet

Local Street Traffic Impact Evaluation for King County Transfer Stations

Prepared for
King County Solid Waste Division

Prepared by
HDR Engineering, Inc.
500 108th Avenue NE, Suite 1200
Bellevue, WA 98004

March 18, 2005



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INTRODUCTION

King County is currently assessing existing conditions at five transfer stations in an effort to determine what improvements could be implemented at some or all of the facilities. The County is evaluating 19 measures of effectiveness, including but not limited to, travel time to the facility, time spent on site, recycling services meet goals, daily handling capacity, safety, meets local noise ordinances, and meets criteria for acceptable traffic impacts on local streets.

This technical report documents the analysis for addressing one of the 19 measures of effectiveness, specifically, Criteria 15 as follows:

15. *Meets Criteria for Acceptable Traffic Impacts on Local Streets*
    a) *Local intersections remain below capacity if additional traffic is added, as defined by the* Highway Capacity Manual
    b) *On average, traffic queues entering the transfer station do not spillover onto or impede local streets during 95 percent of the operating hours*

The five King County transfer stations that were evaluated are:

- Algona Station, located in the City of Algona and having immediate traffic impacts to Algona, Auburn and King County local streets,
- Bow Lake Station, located in the City of Tukwila and having immediate traffic impacts to Seatac, Kent, and King County local streets,
- Factoria Station, located in the City of Bellevue and having immediate traffic impacts to Bellevue local streets,
- Houghton Station, located in the City of Kirkland and having immediate traffic impacts to Kirkland, and
- Renton Station, located in the City of Renton and having immediate traffic impacts to Renton.

The methodology, data collection, and results for Criteria 15 are provided in detail in the following report.

METHODOLOGY

Intersection Analysis

For Criterion 15a, the traffic analysis software program Synchro/SimTraffic was used to analyze local intersections. Most agencies require the analysis of the weekday p.m. peak hour, because it is typically the time period that the local street system is experiencing the most traffic. Although traffic associated with King County transfer stations may not be the highest during the weekday p.m. peak hour, the total volume on the local street system will likely be higher during the weekday p.m. peak hour, than during an hour that demand is highest for a transfer station (typically on a weekend). For this reason the weekday p.m. peak hour was analyzed at each of the study intersections.

A traffic operational analysis (level of service (LOS) and volume-to-capacity calculation) was performed at the intersections selected by each host Agency deemed to be most impacted by transfer station traffic. LOS refers to the degree of congestion at an intersection, measured in average control delay, and based on the methodologies provided in the Highway Capacity Manual. LOS A represents free-flow conditions (motorists experience little or no delay and traffic levels are well below roadway capacity), LOS F represents forced-flow conditions (motorists experience very long delays, in excess of 80 seconds at signalized intersections

and more than 50 seconds at unsignalized intersections, and traffic levels exceed roadway capacity), and LOS B to E represent decreasing desirable conditions. A more detailed discussion of the LOS concept is presented in the technical report.

The volume-to-capacity ratio (v/c) is the peak hour traffic volume (vehicles/hour) at an intersection divided by the maximum traffic volume that the intersection can maintain. For example, when v/c equals 0.85, it can be said that peak hour traffic uses 85 percent of the intersection's capacity; or 15 percent of the capacity is not used. When v/c approaches 1.0 (e.g., 0.95), traffic flow becomes unstable such that small disruptions can cause traffic flow to break down and long traffic queues to form.

If an intersection operates at LOS F or exceeds a v/c of 1.0, Criteria 15a is not achieved.

As mentioned previously, each host Agency selected the intersections that they deemed to be most impacted by transfer station traffic, with the exception of the City of Renton. The intersections analyzed in the City of Renton were selected by the project team in the absence of recommendations directly from the City. Intersection p.m. peak hour turning movement counts and intersection channelization were either obtained directly from the host agency, or collected in the field. The selected intersections are as follows for each transfer station:

Algona
- West Valley Highway/Driveway
- West Valley Highway/15th Street SW
- West Valley Highway/1st Avenue N

Bow Lake
- Orillia Road/Driveway
- S. 188th Street/I-5 NB Ramp
- S. 188th Street/Military Rd.

Factoria
- Richards Road/SE 32nd
- Richards Road/Eastgate Way

Houghton
- 116th Avenue NE/NE 60th Street
- 116th Avenue NE/NE 70th Street
- 116th Avenue NE/I-405 NB ramps
- NE 60th Street/Driveway

Renton
- NE 3rd St/Edmonds Avenue NE
- NE 4th St/Jefferson Avenue NE
- NE 4th St/Union Avenue NE

Queue Analysis

For Criterion 15b, basic queuing theory as described in *Traffic Flow Fundamentals* (Adolf D. May, 1990) was applied to estimate the average queue formed at each transfer station weigh station upon entering. The equation used to estimate the average queue is as follows:

$$E(n) = (2\rho - \rho^2) \div (2(1-\rho))$$

$E(n)$ = average number in system (vehicle)
ρ = traffic intensity

$$\rho = \frac{\lambda}{\mu}$$

λ = mean arrival rate (vehicles per hour)
μ = mean service rate per lane (vehicles per hour)

In addition, the following assumptions were made in order to apply the above queuing equation to the available data:

- Vehicle arrival rate is assumed to be random, that is, vehicles do not arrive at transfer stations at equal increments of time, rather they arrive at "random" times.
- Vehicle service rate is assumed to be constant
- Traffic intensity (volume-to-capacity ratio) must be less than 1.0
- There is only one inbound scale at each transfer station

If the average vehicle queue exceeds the available storage capacity, then the queue is spilling over onto the local street system or impeding local street operations. The available storage capacity was defined as the distance from the inbound transfer station scale to the first driveway or intersection on a local street or a point on the local street at which the queue from the transfer station would impede non-transfer station traffic.

If the average queue exceeds the available storage capacity more than 95 percent of the operating hours, Criteria 15b is not met.

For Criteria 15b, transaction data entering each transfer station was obtained from King County, for every operating hour and every operating day in 2004. That data indicates the hourly demand for each transfer station by vehicle type. Based on two studies performed by King County in the mid 1990's at the Algona, Renton, Bow Lake, and 1st Avenue NE transfer stations, it was determined that the average time spent on the inbound scale is between 22 and 28 seconds. With these two pieces of data (hourly demand and average transaction time) the average vehicle queue waiting to be served entering a transfer station was calculated based on the equations listed above.

At one station, the Bow Lake Transfer Station, each hour was not analyzed. Out of the 22 hours of the day that Bow Lake is open, only the core hours of 8 am to 6 pm for weekdays and 8:30 am to 5:30 pm for weekends were analyzed, so that the data did not skew the results for hours where little traffic is experienced.

Forecasts

Both Criteria 15a and 15b were also analyzed based on 2030 projections, provided by King County. The Solid Waste Division developed the projections using its forecast model. This model predicts waste disposal based on such factors as growth in population, employment, income, and assumptions about additional recycling activity.

RESULTS

Intersection Analysis

The results for Criteria 15a, the intersection operational analysis, are summarized in **Tables 1** and **2** for existing conditions (2005) and 2025, respectively. In 2005, the Algona, Factoria, and Renton transfer stations all meet current intersection LOS standards (Criteria 15a). Both the Bow Lake and Houghton transfer stations have one intersection that does not meet the current intersection LOS standard, meaning, the intersection is LOS F and/or the v/c ratio is greater than or equal to 1.0. At Bow Lake, it is estimated that if there were no vehicles related to the transfer station at the intersection, the intersection would operate below capacity. Conversely, at the Houghton station, the intersection exceeds capacity even without traffic associated with the transfer station.

By 2025, all of the transfer stations have at least one over-capacity intersection impacted by the transfer station, with or without additional growth at the transfer station (see **Table 2** and **Figure 2**)

Figures 1 and **2** illustrate the same information presented in **Tables 1** and **2**, graphically.

Table 1

Criteria 15a - Existing Conditions (2005) Analysis Summary

			Existing w/o Transfer Station				Existing w/ Transfer Station			
Facility	Intersection		Delay (sec/veh)	LOS	V/C	Meets Criteria?	Delay (sec/veh)	LOS	V/C	Meets Criteria?
Algona	WVH/Driveway	STOP	n/a	n/a	0.82	YES	38.4	E	0.83	YES
	WVH/15th St		22.0	C	0.88	YES	22.7	C	0.89	YES
	WVH/1st Ave	STOP	41.8	E	0.39	YES	43.0	E	0.40	YES
Bow Lake	Orillia Rd/Driveway	STOP	n/a	n/a	0.75	YES	>110	F	1.09	NO
	188th St/I-5 NB Rmp		29.0	C	0.94	YES	29.9	C	0.95	YES
	188th St/Military Rd		27.5	C	0.68	YES	27.6	C	0.68	YES
Factoria	Richards Rd/32nd St		13.2	B	0.48	YES	15.1	B	0.50	YES
	Richards Rd/Eastgate		31.5	C	0.81	YES	31.2	C	0.81	YES
Houghton	116th Ave/60th St	STOP	18.8	C	0.80	YES	19.3	C	0.81	YES
	116th Ave/70th St		55.1	E	1.00	NO	55.3	E	1.00	NO
	116th Ave/I-405 NB Rmp		33.7	C	0.93	YES	34.3	C	0.93	YES
	60th St/Driveway	STOP	n/a	n/a	0.08	YES	9.4	A	0.08	YES
Renton	3rd St/Edmonds Ave		13.9	B	0.67	YES	13.9	B	0.67	YES
	4th St/Jefferson Ave		15.6	B	0.75	YES	15.6	B	0.75	YES
	4th St/Union Ave		17.0	B	0.72	YES	17.0	B	0.72	YES

Notes:

1. = signalized intersection, = stop-controlled intersection
2. Delay, or control delay, is measured in seconds per vehicle, and is a measure of all the delay contributable to traffic control measures, such as signals or stop signs. At signalized intersections and all-way stop-controlled intersections, the reported delay is the average of all the control delay experienced for all movements. At one-way and two-way stop-controlled intersections, the reported delay is for only one movement, the movement experiencing the worst control delay, which is typically one of the stop-controlled side street approaches. The control delay reported at two-way stop-controlled intersections is not a valid indication of the operations of the entire intersection.
3. LOS refers to Level of Service and is based on the methodologies outlined in the 2000 *Highway Capacity Manual*. LOS is rated from "A" (low delay) to "F" (delay in excess of 80 seconds per vehicle at signalized intersections, and 50 seconds at unsignalized intersections).
4. V/C = volume-to-capacity ratio
5. n/a = not available because this intersection is stop-controlled and the movement experiencing the worst control delay would be the movement exiting the transfer station, and because this scenario assumes no traffic associated with the transfer station, there is no control delay to report.

Table 2
Criteria 15a - Future Conditions (2025) Analysis Summary

Facility	Intersection	2025 w/o Growth at Transfer Station				2025 w/ Growth at Transfer Station			
		Delay (sec/veh)	LOS	V/C	Meets Criteria?	Delay (sec/veh)	LOS	V/C	Meets Criteria?
Algona	WVH/Driveway	>110	F	1.26	NO	>110	F	1.26	NO
	WVH/15th St	94.3	F	1.28	NO	94.5	F	1.29	NO
	WVH/1st Ave	>110	F	n/c	NO	>110	F	n/c	NO
Bow Lake	Orillia Rd/Driveway	>110	F	n/c	NO	>110	F	n/c	NO
	188th St/I-5 NB Rmp	>110	F	1.52	NO	>110	F	1.54	NO
	188th St/Military Rd	51.0	D	0.99	YES	51.5	D	0.99	YES
Factoria	Richards Rd/32nd St	24.2	C	0.76	YES	26.6	C	0.79	YES
	Richards Rd/Eastgate	>110	F	1.23	NO	>110	F	1.23	NO
Houghton	116th Ave/60th St	>110	F	1.37	NO	>110	F	1.44	NO
	116th Ave/70th St	>110	F	1.51	NO	>110	F	1.51	NO
	116th Ave/I-405 NB Rmp	>110	F	1.32	NO	>110	F	1.33	NO
	60th St/Driveway	10.2	B	0.12	YES	10.7	B	0.12	YES
Renton	3rd St/Edmonds Ave	21.8	C	0.95	YES	21.8	C	0.95	YES
	4th St/Jefferson Ave	17.8	B	0.85	YES	18.4	B	0.86	YES
	4th St/Union Ave	90.6	F	1.13	NO	91.3	F	1.13	NO

Notes:

1. = signalized intersection, = stop-controlled intersection
2. Delay, or control delay, is measured in seconds per vehicle, and is a measure of all the delay contributable to traffic control measures, such as signals or stop signs. At signalized intersections and all-way stop-controlled intersections, the reported delay is the average of all the control delay experienced for all movements. At one-way and two-way stop-controlled intersections, the reported delay is for only one movement, the movement experiencing the worst control delay, which is typically one of the stop-controlled side street approaches. The control delay reported at two-way stop-controlled intersections is not a valid indication of the operations of the entire intersection.
3. LOS refers to Level of Service and is based on the methodologies outlined in the 2000 *Highway Capacity Manual*. LOS is rated from "A" (low delay) to "F" (delay in excess of 80 seconds per vehicle at signalized intersections, and 50 seconds at unsignalized intersections).
4. V/C = volume-to-capacity ratio
5. n/c = the volume-to-capacity ratio exceeds calculable limits.

Figure 1
Criteria 15a - Existing Conditions (2005) Analysis Summary

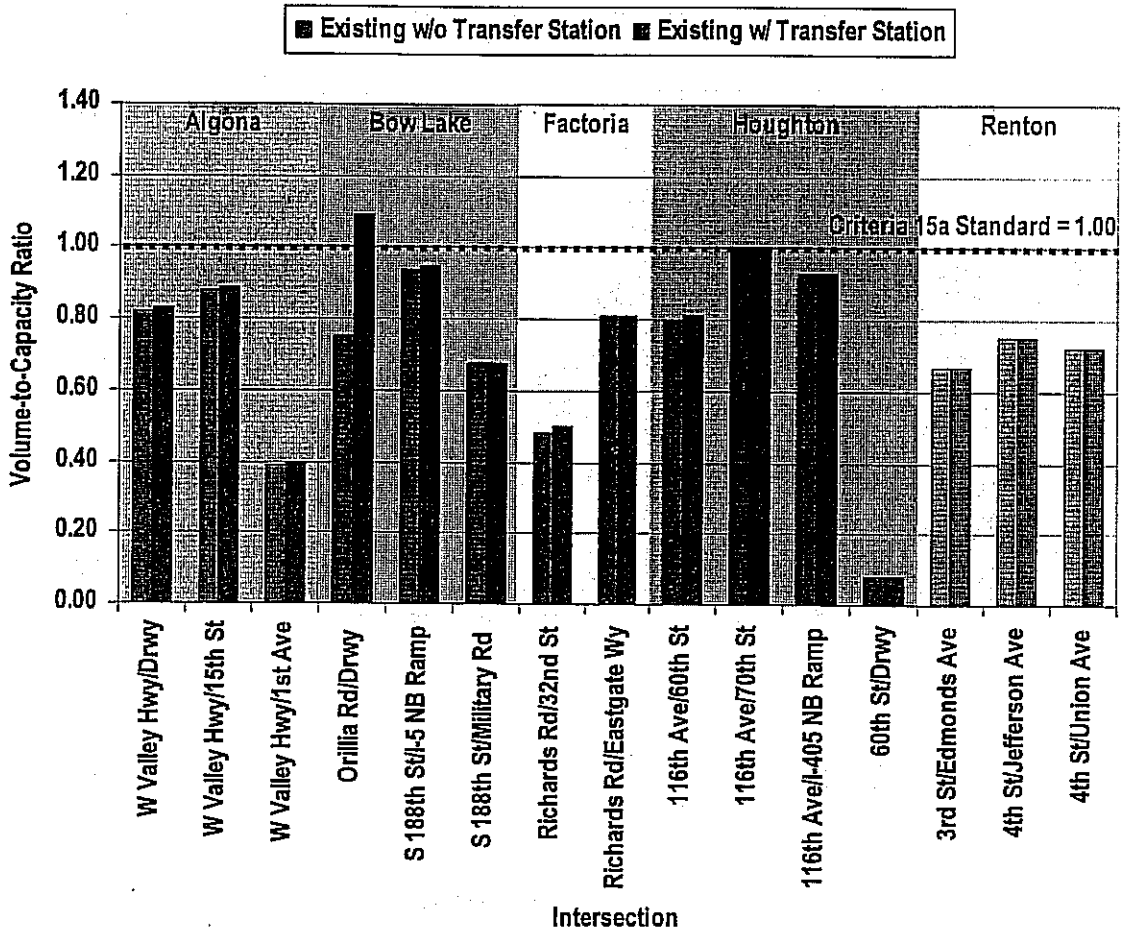
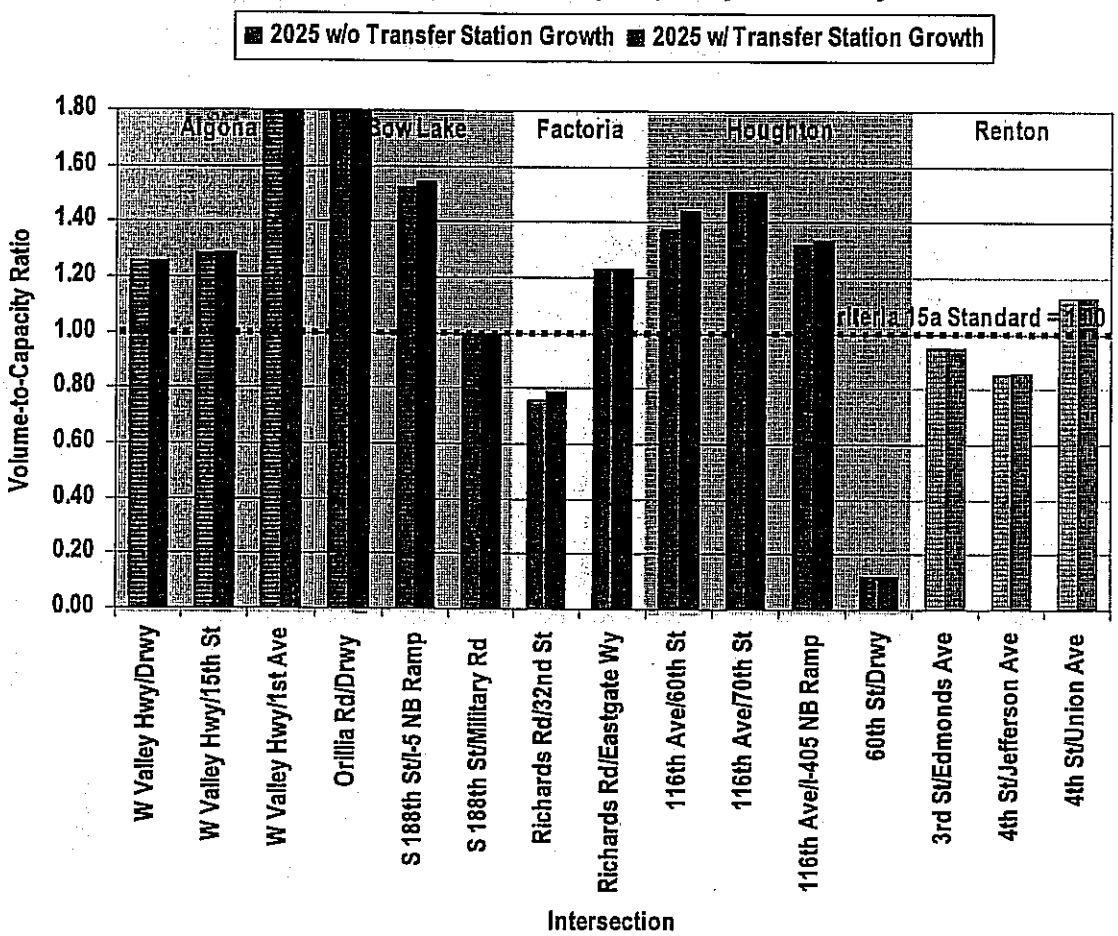


Figure 2
Criteria 15a - Future Conditions (2025) Analysis Summary



Queue Analysis

In order to determine if the average queue at each of the transfer stations exceed available storage, the average vehicle length must be calculated. The average vehicle length was calculated based on the mix of passenger cars versus transfer station trucks at each facility, and assuming 25 feet per passenger car and 75 feet per transfer station truck. The average vehicle length is summarized in **Table 3**.

Table 3
Average Queue Capacity by Site

Facility	Average Vehicle Length (feet)	On-Site Queue Capacity	
		Length (feet)	No. of Vehicles
Algona	27.4	135	4
Bow Lake	32.5	476	14
Factoria	26.8	64	2
Houghton	28.6	346	12
Renton	26.5	70	2

Notes:

1. The average vehicle length was calculated based on the average mix of passenger cars versus transfer station trucks at each facility, and assuming 25 feet per passenger car and 75 feet per transfer station truck.
2. The queue capacity was provided by King County and is the distance from the weigh station to the first off-site intersection or driveway that would be impacted by the queue of vehicles at the transfer station.

The 2004 existing condition results of the Criteria 15b analysis, queuing, are presented in **Table 4**. Based on all data available in 2004 from January to December, only the Renton transfer station meets Criteria 15b, where traffic queues entering the transfer station do not spillover onto or impede local streets during 95 percent of the operating hours. The data was further analyzed to determine if the majority of the off-site queuing took place on the weekend or weekday. In fact, all of the transfer station sites would meet the queue criteria on a weekday, i.e. none of the sites queue off-site more than 95 percent of the operating hours on a weekday. Conversely, all of the transfer stations fail the criteria 15b on weekends.

Table 4
Criteria 15b – Queue Capacity Analysis Summary
All Days in 2004

Facility	Days of Week Analyzed	Total Hours Analyzed	No. of Hours Queue Exceeds Capacity	Percent of Hours Queue Exceeds Capacity	Meets Criteria?
Algona	Weekday	2,995	45	2%	YES
	Weekend	1,002	454	44%	NO
	All Days	4,017	499	12%	NO
Bow Lake	Weekday	2,615	20	1%	YES
	Weekend	1,007	286	28%	NO
	All Days	3,622	306	8%	NO
Factoria	Weekday	4,010	35	1%	YES
	Weekend	1,018	415	41%	NO
	All Days	5,028	450	9%	NO
Houghton	Weekday	2,485	15	1%	YES
	Weekend	1,014	171	17%	NO
	All Days	3,499	186	5%	NO
Renton	Weekday	2,658	1	0%	YES
	Weekend	1,022	81	8%	NO
	All Days	3,680	82	2%	YES

It should be noted that at the Bow Lake transfer station, the analysis for Criteria 5, which evaluated the on-site capacity of each transfer station, indicated that station has adequate capacity (LOS C) in 2005 on site to handle existing traffic flows. Therefore, the fact that Bow Lake does not meet the off-site queue criteria would indicate that the off-site queue is not related to the on-site capacity for this station. Rather, the constraint is the process time at the scale.

King County implemented new operating hours and made some functional changes at all of the transfer stations in the latter half of 2004, specifically July to December. As a result, the queue data was re-analyzed using data from only the latter half of the year to determine if the hours of operation and functional changes would have made a difference with respect to off-site queuing. **Table 5** summarizes the queue analysis results for data represented by July to December 2004. Both Renton and Houghton meet Criteria 15b, when only the latter half of 2004 is analyzed. as well. Similar to the data analysis for the full year, all of the sites meet Criteria 15b on a weekday, while none of them meet the criteria on a weekend. With the exception of the Algona transfer station, all of the transfer stations experienced fewer occurrences of the queue spilling over onto City streets or impeding traffic flow.

Table 5
Criteria 15b – Queue Capacity Analysis Summary
July to December in 2004

Facility	Days of Week Analyzed	Total Hours Analyzed	No. of Hours Queue Exceeds Capacity	Percent of Hours Queue Exceeds Capacity	Meets Criteria?
Algona	Weekday	1,458	40	3%	YES
	Weekend	491	221	45%	NO
	All Days	1,949	261	13%	NO
Bow Lake	Weekday	1,308	18	1%	YES
	Weekend	487	107	22%	NO
	All Days	1,795	125	7%	NO
Factoria	Weekday	1,786	26	1%	YES
	Weekend	490	184	38%	NO
	All Days	2,276	210	9%	NO
Houghton	Weekday	1,199	14	1%	YES
	Weekend	489	69	14%	NO
	All Days	1,688	83	5%	YES
Renton	Weekday	1,326	1	0%	YES
	Weekend	493	29	6%	NO
	All Days	1,819	30	2%	YES

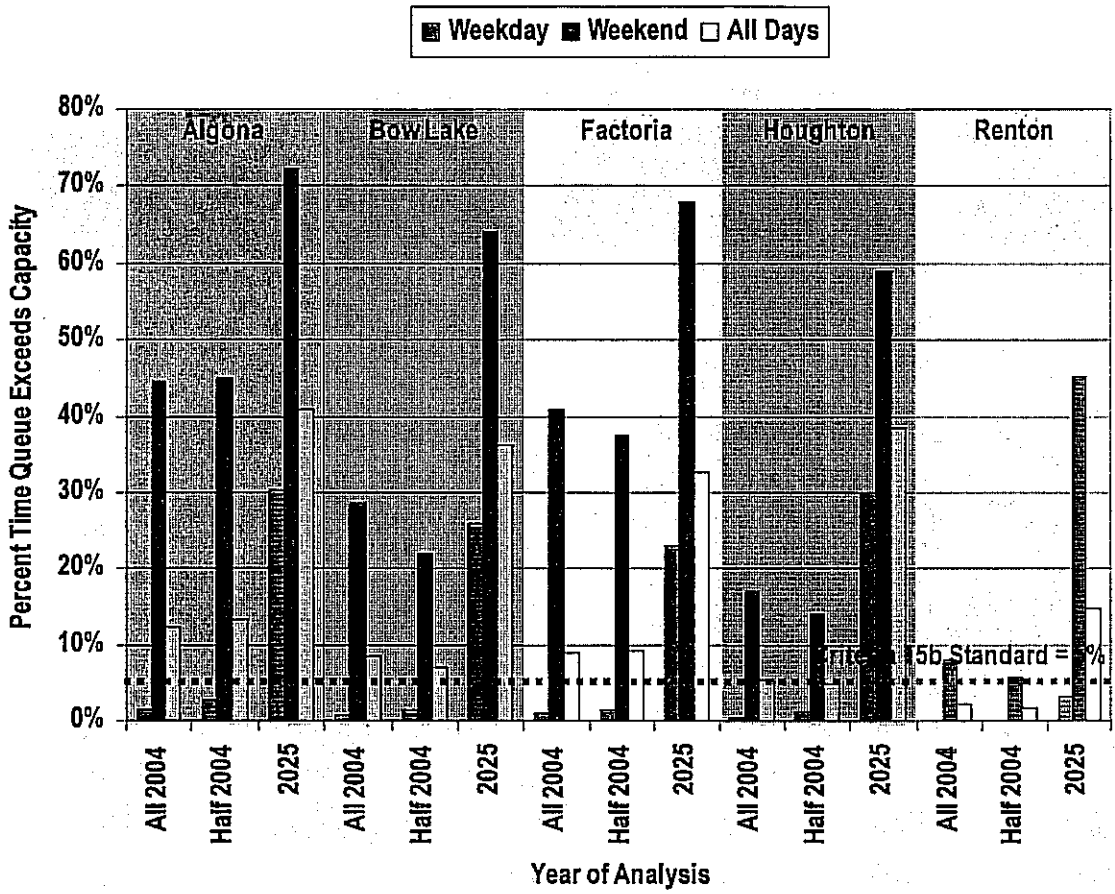
Table 6 summarizes the queue analysis based on 2025 projections of transfer station use. By 2025, none of the facilities will satisfy Criteria 15b, with queues extending off-site between 15 and 41 percent of the time, depending on the location. In fact, even weekdays will experience queue failure at all the transfer stations, with the exception of Renton.

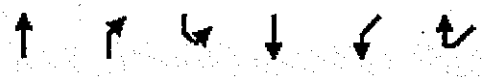
Table 6
Criteria 15b – 2025 Queue Capacity Analysis Summary

Facility	Days of Week Analyzed	Total Hours Analyzed	No. of Hours Queue Exceeds Capacity	Percent of Hours Queue Exceeds Capacity	Meets Criteria?
Algona	Weekday	1,458	442	30%	NO
	Weekend	490	354	72%	NO
	All Days	1,948	796	41%	NO
Bow Lake	Weekday	1,308	339	26%	NO
	Weekend	487	312	64%	NO
	All Days	1,795	651	36%	NO
Factoria	Weekday	1,786	412	23%	NO
	Weekend	490	333	68%	NO
	All Days	2,276	745	33%	NO
Houghton	Weekday	1,199	360	30%	NO
	Weekend	488	288	59%	NO
	All Days	1,687	648	38%	NO
Renton	Weekday	1,326	43	3%	YES
	Weekend	493	223	45%	NO
	All Days	1,819	266	15%	NO

Figure 3 illustrates the data provided **Tables 4, 5,** and **6,** graphically.

Figure 3
Criteria 15b – Queue Capacity Analysis Summary





Movement	NBT	NBR	SBL	SBT	SWL	SWR
Lane Configurations						
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Volume (veh/h)	1753	8	19	1444	8	21
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	1905	9	21	1570	9	23
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (ft)				244		
pX, platoon unblocked					0.76	
vC, conflicting volume			1914		2736	957
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			1914		2964	957
tC, single (s)			4.1		6.8	6.9
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			93		0	91
cM capacity (veh/h)			306		8	258

Direction, Lane #	NB 1	NB 2	SB 1	SB 2	SB 3	SW 1	SW 2
Volume Total	1270	644	21	785	785	9	23
Volume Left	0	0	21	0	0	9	0
Volume Right	0	9	0	0	0	0	23
cSH	1700	1700	306	1700	1700	8	258
Volume to Capacity	0.75	0.38	0.07	0.46	0.46	1.09	0.09
Queue Length 95th (ft)	0	0	5	0	0	46	7
Control Delay (s)	0.0	0.0	17.6	0.0	0.0	944.9	20.3
Lane LOS			C			F	C
Approach Delay (s)	0.0		0.2			275.4	
Approach LOS						F	

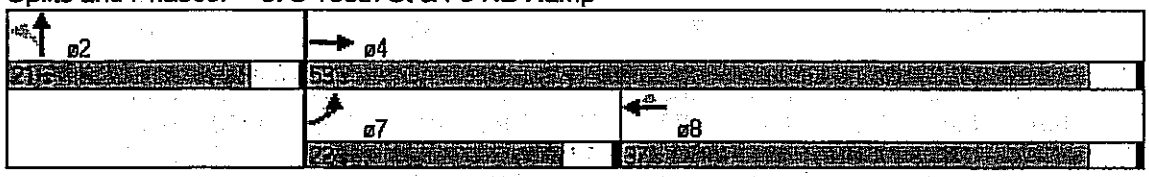
Intersection Summary			
Average Delay	2.6		
Intersection Capacity Utilization	58.7%	ICU Level of Service	B
Analysis Period (min)	15		

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Turning Speed (mph)	15		9	15		9	15		9	15		9
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	0.95	0.95	1.00	1.00	1.00	1.00
Frt						0.850		0.932				
Flt Protected	0.950						0.950	0.974				
Satd. Flow (prot)	1770	3539	0	0	3539	1583	1681	1606	0	0	0	0
Flt Permitted	0.950						0.950	0.974				
Satd. Flow (perm)	1770	3539	0	0	3539	1583	1681	1606	0	0	0	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)						580		47				
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		650			244			835			894	
Travel Time (s)		14.8			5.5			19.0			20.3	
Volume (vph)	367	1362	0	0	884	923	397	1	117	0	0	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	399	1480	0	0	961	1003	432	1	127	0	0	0
Lane Group Flow (vph)	399	1480	0	0	961	1003	280	280	0	0	0	0
Turn Type	Prot					Perm	Perm					
Protected Phases	7	4			8			2				
Permitted Phases						8	2					
Total Split (s)	22.0	59.0	0.0	0.0	37.0	37.0	21.0	21.0	0.0	0.0	0.0	0.0
Act Effct Green (s)	18.0	55.0			33.0	33.0	17.0	17.0				
Actuated g/C Ratio	0.22	0.69			0.41	0.41	0.21	0.21				
v/c Ratio	1.00	0.61			0.66	1.01	0.78	0.74				
Control Delay	79.6	8.0			21.6	43.1	47.3	38.1				
Queue Delay	0.0	0.0			0.0	0.0	0.0	0.0				
Total Delay	79.6	8.0			21.6	43.1	47.3	38.1				
LOS	E	A			C	D	D	D				
Approach Delay		23.2			32.6			42.7				
Approach LOS		C			C			D				
Stops (vph)	309	666			682	410	225	192				
Fuel Used(gal)	10	16			9	12	5	5				
CO Emissions (g/hr)	726	1123			653	848	378	331				
NOx Emissions (g/hr)	141	218			127	165	74	64				
VOC Emissions (g/hr)	168	260			151	196	88	77				
Dilemma Vehicles (#)	0	0			0	0	0	0				
Queue Length 50th (ft)	201	177			197	278	140	114				
Queue Length 95th (ft)	#378	231			263	#578	#267	#234				
Internal Link Dist (ft)		570			164			755			814	
Turn Bay Length (ft)												
Base Capacity (vph)	398	2433			1460	994	357	378				
Starvation Cap Reductn	0	0			0	0	0	0				
Spillback Cap Reductn	0	0			0	0	0	0				
Storage Cap Reductn	0	0			0	0	0	0				
Reduced v/c Ratio	1.00	0.61			0.66	1.01	0.78	0.74				

Intersection Summary

Area Type: Other
Cycle Length: 80
Actuated Cycle Length: 80
Offset: 0 (0%), Referenced to phase 2:NBTL and 6:, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.01
Intersection Signal Delay: 29.9 Intersection LOS: C
Intersection Capacity Utilization 102.1% ICU Level of Service G
Analysis Period (min) 15
~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 3: S 188th St & I-5 NB Ramp

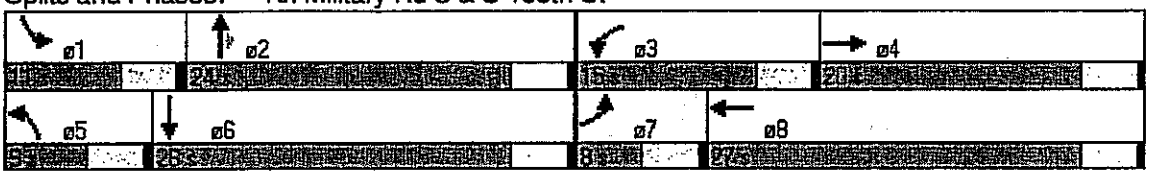


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Turning Speed (mph)	15		9	15		9	15		9	15		9
Lane Util. Factor	1.00	1.00	1.00	0.97	1.00	1.00	1.00	0.95	1.00	1.00	0.91	0.91
Frt		0.992			0.965				0.850		0.996	
Flt Protected	0.950			0.950			0.950			0.950		
Satd. Flow (prot)	1770	1848	0	3433	1798	0	1770	3539	1583	1770	5065	0
Flt Permitted	0.950			0.950			0.950			0.950		
Satd. Flow (perm)	1770	1848	0	3433	1798	0	1770	3539	1583	1770	5065	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		4			23				298		6	
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		1070			798			306			408	
Travel Time (s)		24.3			18.1			7.0			9.3	
Volume (vph)	15	128	7	379	280	86	71	635	274	103	1167	34
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	16	139	8	412	304	93	77	690	298	112	1268	37
Lane Group Flow (vph)	16	147	0	412	397	0	77	690	298	112	1305	0
Turn Type	Prot			Prot			Prot		Perm	Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases									2			
Total Split (s)	8.0	20.0	0.0	15.0	27.0	0.0	9.0	24.0	24.0	11.0	26.0	0.0
Act Effct Green (s)	4.0	16.0		11.0	23.0		5.0	20.0	20.0	7.0	22.0	
Actuated g/C Ratio	0.06	0.23		0.16	0.33		0.07	0.29	0.29	0.10	0.31	
v/c Ratio	0.16	0.35		0.76	0.66		0.61	0.68	0.45	0.63	0.82	
Control Delay	35.1	24.7		39.3	25.0		54.4	26.3	5.2	48.4	27.3	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Delay	35.1	24.7		39.3	25.0		54.4	26.3	5.2	48.4	27.3	
LOS	D	C		D	C		D	C	A	D	C	
Approach Delay		25.8			32.3			22.4			28.9	
Approach LOS		C			C			C			C	
Stops (vph)	18	107		341	288		63	541	34	93	1045	
Fuel Used(gal)	0	2		7	6		2	11	3	2	16	
CO Emissions (g/hr)	23	168		508	400		116	777	176	130	1137	
NOx Emissions (g/hr)	5	33		99	78		23	151	34	25	221	
VOC Emissions (g/hr)	5	39		118	93		27	180	41	30	264	
Dilemma Vehicles (#)	0	0		0	0		0	0	0	0	0	
Queue Length 50th (ft)	7	52		88	135		33	137	0	47	187	
Queue Length 95th (ft)	25	100		#149	226		#92	194	52	#114	239	
Internal Link Dist (ft)		990			718			226			328	
Turn Bay Length (ft)												
Base Capacity (vph)	101	425		539	606		126	1011	665	177	1596	
Starvation Cap Reductn	0	0		0	0		0	0	0	0	0	
Spillback Cap Reductn	0	0		0	0		0	0	0	0	0	
Storage Cap Reductn	0	0		0	0		0	0	0	0	0	
Reduced v/c Ratio	0.16	0.35		0.76	0.66		0.61	0.68	0.45	0.63	0.82	

Intersection Summary

Area Type: Other
Cycle Length: 70
Actuated Cycle Length: 70
Offset: 0 (0%), Referenced to phase 2:NBT and 6:SBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.82
Intersection Signal Delay: 27.6 Intersection LOS: C
Intersection Capacity Utilization 63.9% ICU Level of Service B
Analysis Period (min): 15
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 10: Military Rd S & S 188th St



Movement	NBT	NBR	SBL	SBT	SWL	SWR
Lane Configurations						
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Volume (veh/h)	1753	0	0	1444	0	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	1905	0	0	1570	0	0
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (ft)				244		
pX, platoon unblocked					0.76	
vC, conflicting volume			1905		2690	953
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			1905		2906	953
tC, single (s)			4.1		6.8	6.9
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			100		100	100
cM capacity (veh/h)			308		9	260

Direction, Lane #	NB 1	NB 2	SB 1	SB 2	SB 3	SW 1	SW 2
Volume Total	1270	635	0	785	785	0	0
Volume Left	0	0	0	0	0	0	0
Volume Right	0	0	0	0	0	0	0
cSH	1700	1700	1700	1700	1700	1700	1700
Volume to Capacity	0.75	0.37	0.00	0.46	0.46	0.00	0.00
Queue Length 95th (ft)	0	0	0	0	0	0	0
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lane LOS						A	A
Approach Delay (s)	0.0		0.0			0.0	
Approach LOS						A	

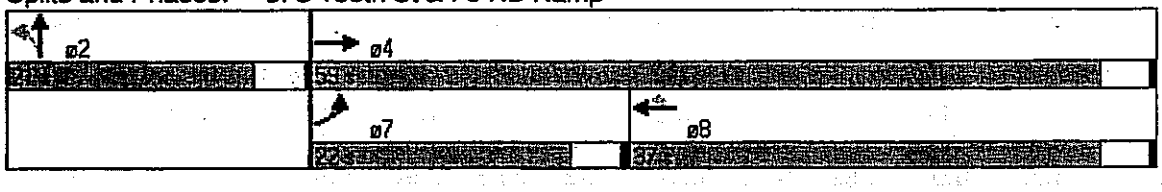
Intersection Summary			
Average Delay	0.0		
Intersection Capacity Utilization	51.8%	ICU Level of Service	A
Analysis Period (min)	15		

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Turning Speed (mph)	15		9	15		9	15		9	15		9
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	0.95	0.95	1.00	1.00	1.00	1.00
Frt						0.850		0.936				
Flt Protected	0.950						0.950	0.972				
Satd. Flow (prot)	1770	3539	0	0	3539	1583	1681	1610	0	0	0	0
Flt Permitted	0.950						0.950	0.972				
Satd. Flow (perm)	1770	3539	0	0	3539	1583	1681	1610	0	0	0	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)						580		42				
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		650			244			835			894	
Travel Time (s)		14.8			5.5			19.0			20.3	
Volume (vph)	367	1362	0	0	874	912	397	1	107	0	0	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	399	1480	0	0	950	991	432	1	116	0	0	0
Lane Group Flow (vph)	399	1480	0	0	950	991	276	273	0	0	0	0
Turn Type	Prot					Perm	Perm					
Protected Phases	7	4			8			2				
Permitted Phases						8	2					
Total Split (s)	22.0	59.0	0.0	0.0	37.0	37.0	21.0	21.0	0.0	0.0	0.0	0.0
Act Effct Green (s)	18.0	55.0			33.0	33.0	17.0	17.0				
Actuated g/C Ratio	0.22	0.69			0.41	0.41	0.21	0.21				
v/c Ratio	1.00	0.61			0.65	1.00	0.77	0.73				
Control Delay	79.6	8.0			21.5	39.9	46.3	37.8				
Queue Delay	0.0	0.0			0.0	0.0	0.0	0.0				
Total Delay	79.6	8.0			21.5	39.9	46.3	37.8				
LOS	E	A			C	D	D	D				
Approach Delay		23.2			30.9			42.1				
Approach LOS		C			C			D				
Stops (vph)	309	666			672	402	223	189				
Fuel Used(gal)	10	16			9	11	5	5				
CO Emissions (g/hr)	726	1123			643	794	369	322				
NOx Emissions (g/hr)	141	218			125	155	72	63				
VOC Emissions (g/hr)	168	260			149	184	86	75				
Dilemma Vehicles (#)	0	0			0	0	0	0				
Queue Length 50th (ft)	201	177			194	249	137	113				
Queue Length 95th (ft)	#378	231			258	#563	#261	#229				
Internal Link Dist (ft)		570			164			755			814	
Turn Bay Length (ft)												
Base Capacity (vph)	398	2433			1460	994	357	375				
Starvation Cap Reductn	0	0			0	0	0	0				
Spillback Cap Reductn	0	0			0	0	0	0				
Storage Cap Reductn	0	0			0	0	0	0				
Reduced v/c Ratio	1.00	0.61			0.65	1.00	0.77	0.73				

Intersection Summary

Area Type: Other
Cycle Length: 80
Actuated Cycle Length: 80
Offset: 0 (0%), Referenced to phase 2:NBTL and 6:, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.00
Intersection Signal Delay: 29.0 Intersection LOS: C
Intersection Capacity Utilization 101.1% ICU Level of Service G
Analysis Period (min) 15
~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 3: S 188th St & I-5 NB Ramp

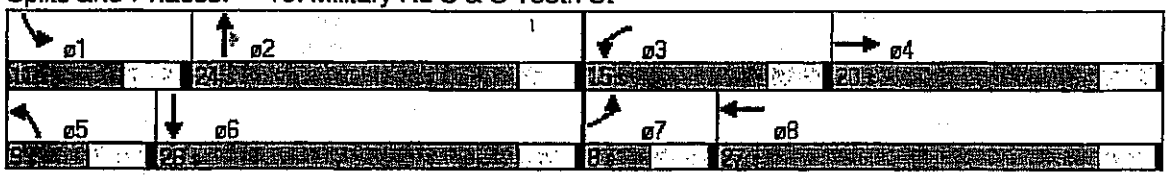


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Turning Speed (mph)	15		9	15		9	15		9	15		9
Lane Util. Factor	1.00	1.00	1.00	0.97	1.00	1.00	1.00	0.95	1.00	1.00	0.91	0.91
Frt		0.992			0.965				0.850		0.996	
Flt Protected	0.950			0.950			0.950			0.950		
Satd. Flow (prot)	1770	1848	0	3433	1798	0	1770	3539	1583	1770	5065	0
Flt Permitted	0.950			0.950			0.950			0.950		
Satd. Flow (perm)	1770	1848	0	3433	1798	0	1770	3539	1583	1770	5065	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		4			23				298		6	
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		1070			798			306			408	
Travel Time (s)		24.3			18.1			7.0			9.3	
Volume (vph)	15	128	7	378	280	86	71	630	274	103	1165	34
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	16	139	8	411	304	93	77	685	298	112	1266	37
Lane Group Flow (vph)	16	147	0	411	397	0	77	685	298	112	1303	0
Turn Type	Prot			Prot			Prot		Perm	Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases									2			
Total Split (s)	8.0	20.0	0.0	15.0	27.0	0.0	9.0	24.0	24.0	11.0	26.0	0.0
Act Effct Green (s)	4.0	16.0		11.0	23.0		5.0	20.0	20.0	7.0	22.0	
Actuated g/C Ratio	0.06	0.23		0.16	0.33		0.07	0.29	0.29	0.10	0.31	
v/c Ratio	0.16	0.35		0.76	0.66		0.61	0.68	0.45	0.63	0.82	
Control Delay	35.1	24.7		39.1	25.0		54.4	26.2	5.2	48.4	27.2	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Delay	35.1	24.7		39.1	25.0		54.4	26.2	5.2	48.4	27.2	
LOS	D	C		D	C		D	C	A	D	C	
Approach Delay		25.8			32.2			22.3			28.9	
Approach LOS		C			C			C			C	
Stops (vph)	18	107		340	288		63	535	34	93	1043	
Fuel Used(gal)	0	2		7	6		2	11	3	2	16	
CO Emissions (g/hr)	23	168		506	400		116	770	176	130	1134	
NOx Emissions (g/hr)	5	33		99	78		23	150	34	25	221	
VOC Emissions (g/hr)	5	39		117	93		27	178	41	30	263	
Dilemma Vehicles (#)	0	0		0	0		0	0	0	0	0	
Queue Length 50th (ft)	7	52		88	135		33	136	0	47	186	
Queue Length 95th (ft)	25	100		#148	226		#92	192	52	#114	239	
Internal Link Dist (ft)		990			718			226			328	
Turn Bay Length (ft)												
Base Capacity (vph)	101	425		539	606		126	1011	665	177	1596	
Starvation Cap Reductn	0	0		0	0		0	0	0	0	0	
Spillback Cap Reductn	0	0		0	0		0	0	0	0	0	
Storage Cap Reductn	0	0		0	0		0	0	0	0	0	
Reduced v/c Ratio	0.16	0.35		0.76	0.66		0.61	0.68	0.45	0.63	0.82	

Intersection Summary

Area Type: Other
Cycle Length: 70
Actuated Cycle Length: 70
Offset: 0 (0%), Referenced to phase 2:NBT and 6:SBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.82
Intersection Signal Delay: 27.5 Intersection LOS: C
Intersection Capacity Utilization 63.8% ICU Level of Service B
Analysis Period (min) 15
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 10: Military Rd S & S 188th St

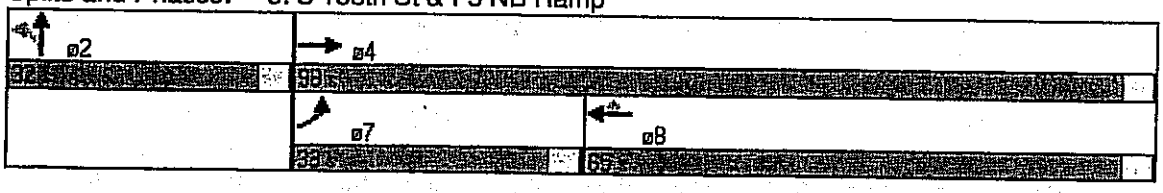


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Turning Speed (mph)	15		9	15		9	15		9	15		9
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	0.95	0.95	1.00	1.00	1.00	1.00
Frt						0.850		0.930				
Flt Protected	0.950						0.950	0.974				
Satd. Flow (prot)	1770	3539	0	0	3539	1583	1681	1603	0	0	0	0
Flt Permitted	0.950						0.950	0.974				
Satd. Flow (perm)	1770	3539	0	0	3539	1583	1681	1603	0	0	0	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)						544		16				
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		650			244			835			894	
Travel Time (s)		14.8			5.5			19.0			20.3	
Volume (vph)	556	2064	0	0	1340	1399	602	2	177	0	0	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	604	2243	0	0	1457	1521	654	2	192	0	0	0
Lane Group Flow (vph)	604	2243	0	0	1457	1521	439	409	0	0	0	0
Turn Type	Prot					Perm	Perm					
Protected Phases	7	4			8			2				
Permitted Phases						8	2					
Total Split (s)	33.0	98.0	0.0	0.0	65.0	65.0	32.0	32.0	0.0	0.0	0.0	0.0
Act Effct Green (s)	29.0	94.0			61.0	61.0	28.0	28.0				
Actuated g/C Ratio	0.22	0.72			0.47	0.47	0.22	0.22				
v/c Ratio	1.53	0.88			0.88	1.47	1.21	1.14				
Control Delay	285.8	18.9			38.5	239.1	161.9	136.0				
Queue Delay	0.0	2.6			0.0	0.0	0.0	0.0				
Total Delay	285.8	21.4			38.5	239.1	161.9	136.0				
LOS	F	C			D	F	F	F				
Approach Delay		77.5			141.0			149.4				
Approach LOS		E			F			F				
Stops (vph)	402	1505			1162	734	327	301				
Fuel Used(gal)	39	32			19	75	18	15				
CO Emissions (g/hr)	2706	2211			1361	5230	1241	1015				
NOx Emissions (g/hr)	527	430			265	1018	241	197				
VOC Emissions (g/hr)	627	512			315	1212	288	235				
Dilemma Vehicles (#)	0	0			0	0	0	0				
Queue Length 50th (ft)	~712	672			570	~1513	~475	~413				
Queue Length 95th (ft)	#941	805			678	#1783	#694	#632				
Internal Link Dist (ft)		570			164			755			814	
Turn Bay Length (ft)												
Base Capacity (vph)	395	2559			1661	1032	362	358				
Starvation Cap Reductn	0	209			0	0	0	0				
Spillback Cap Reductn	0	0			0	0	0	0				
Storage Cap Reductn	0	0			0	0	0	0				
Reduced v/c Ratio	1.53	0.95			0.88	1.47	1.21	1.14				

Intersection Summary

Area Type: Other
Cycle Length: 130
Actuated Cycle Length: 130
Offset: 0 (0%), Referenced to phase 2:NBTL and 6:, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.53
Intersection Signal Delay: 115.0 Intersection LOS: F
Intersection Capacity Utilization 149.6% ICU Level of Service H
Analysis Period (min) 15
~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 3: S 188th St & I-5 NB Ramp

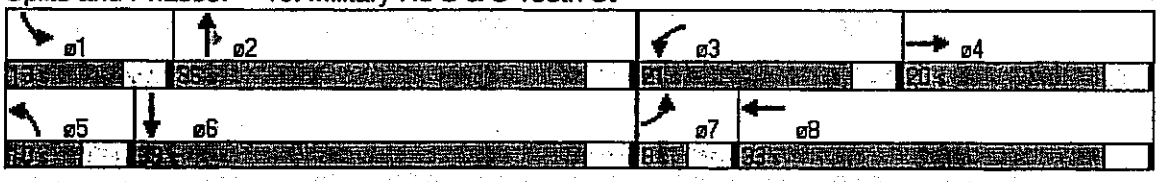


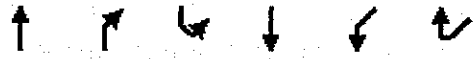
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Turning Speed (mph)	15		9	15		9	15		9	15		9
Lane Util. Factor	1.00	1.00	1.00	0.97	1.00	1.00	1.00	0.95	1.00	1.00	0.91	0.91
Frt		0.992			0.965				0.850		0.996	
Flt Protected	0.950			0.950			0.950			0.950		
Satd. Flow (prot)	1770	1848	0	3433	1798	0	1770	3539	1583	1770	5065	0
Flt Permitted	0.950			0.950			0.950			0.950		
Satd. Flow (perm)	1770	1848	0	3433	1798	0	1770	3539	1583	1770	5065	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		3			18				451		6	
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		1070			798			306			408	
Travel Time (s)		24.3			18.1			7.0			9.3	
Volume (vph)	23	194	11	574	424	130	108	962	415	156	1769	52
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	25	211	12	624	461	141	117	1046	451	170	1923	57
Lane Group Flow (vph)	25	223	0	624	602	0	117	1046	451	170	1980	0
Turn Type	Prot			Prot			Prot		Perm	Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases									2			
Total Split (s)	8.0	20.0	0.0	21.0	33.0	0.0	10.0	36.0	36.0	13.0	39.0	0.0
Act Effct Green (s)	4.0	16.0		17.0	29.0		6.0	32.0	32.0	9.0	35.0	
Actuated g/C Ratio	0.04	0.18		0.19	0.32		0.07	0.36	0.36	0.10	0.39	
v/c Ratio	0.32	0.67		0.96	1.02		0.99	0.83	0.53	0.96	1.00	
Control Delay	52.4	45.5		64.9	72.6		126.1	33.6	4.6	101.2	49.5	
Queue Delay	0.0	1.1		6.5	0.0		0.0	0.0	0.0	0.0	0.7	
Total Delay	52.4	46.5		71.5	72.6		126.1	33.6	4.6	101.2	50.1	
LOS	D	D		E	E		F	C	A	F	D	
Approach Delay		47.1			72.0			32.2			54.2	
Approach LOS		D			E			C			D	
Stops (vph)	25	185		508	459		87	839	38	130	1606	
Fuel Used(gal)	1	5		14	14		4	18	4	4	33	
CO Emissions (g/hr)	40	324		976	991		284	1286	258	309	2308	
NOx Emissions (g/hr)	8	63		190	193		55	250	50	60	449	
VOC Emissions (g/hr)	9	75		226	230		66	298	60	72	535	
Dilemma Vehicles (#)	0	0		0	0		0	0	0	0	0	
Queue Length 50th (ft)	14	118		182	344		68	282	0	98	406	
Queue Length 95th (ft)	40	#207		#290	#565		#177	364	62	#223	#532	
Internal Link Dist (ft)		990			718			226			328	
Turn Bay Length (ft)												
Base Capacity (vph)	79	331		648	592		118	1258	853	177	1973	
Starvation Cap Reductn	0	0		0	0		0	0	0	0	0	
Spillback Cap Reductn	0	22		22	0		0	0	0	0	5	
Storage Cap Reductn	0	0		0	0		0	0	0	0	0	
Reduced v/c Ratio	0.32	0.72		1.00	1.02		0.99	0.83	0.53	0.96	1.01	

Intersection Summary

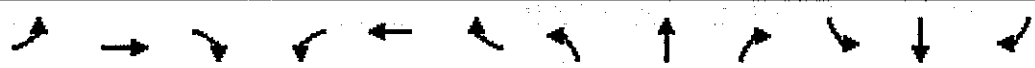
Area Type: Other
Cycle Length: 90
Actuated Cycle Length: 90
Offset: 0 (0%), Referenced to phase 2:NBT and 6:SBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.02
Intersection Signal Delay: 51.3 Intersection LOS: D
Intersection Capacity Utilization 88.2% ICU Level of Service E
Analysis Period (min) 15
~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 10: Military Rd S & S 188th St





Movement	NBT	NBR	SBL	SBT	SWL	SWR
Lane Configurations						
Sign Control	Free			Free	Stop	



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Turning Speed (mph)	15		9	15		9	15		9	15		9
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	0.95	0.95	1.00	1.00	1.00	1.00
Frt						0.850		0.930				
Flt Protected	0.950						0.950	0.974				
Satd. Flow (prot)	1770	3539	0	0	3539	1583	1681	1603	0	0	0	0
Flt Permitted	0.950						0.950	0.974				
Satd. Flow (perm)	1770	3539	0	0	3539	1583	1681	1603	0	0	0	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)						551		16				
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		650			244			835			894	
Travel Time (s)		14.8			5.5			19.0			20.3	
Volume (vph)	556	2064	0	0	1362	1421	602	2	177	0	0	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	604	2243	0	0	1480	1545	654	2	192	0	0	0
Lane Group Flow (vph)	604	2243	0	0	1480	1545	439	409	0	0	0	0
Turn Type	Prot					Perm	Perm					
Protected Phases	7	4			8			2				
Permitted Phases						8	2					
Total Split (s)	32.0	98.0	0.0	0.0	66.0	66.0	32.0	32.0	0.0	0.0	0.0	0.0
Act Effct Green (s)	28.0	94.0			62.0	62.0	28.0	28.0				
Actuated g/C Ratio	0.22	0.72			0.48	0.48	0.22	0.22				
v/c Ratio	1.59	0.88			0.88	1.48	1.21	1.14				
Control Delay	309.9	18.9			37.8	242.2	161.9	136.0				
Queue Delay	0.0	2.6			0.0	0.0	0.0	0.0				
Total Delay	309.9	21.4			37.8	242.2	161.9	136.0				
LOS	F	C			D	F	F	F				
Approach Delay		82.6			142.2			149.4				
Approach LOS		F			F			F				
Stops (vph)	395	1505			1178	744	327	301				
Fuel Used(gal)	41	32			20	77	18	15				
CO Emissions (g/hr)	2894	2211			1369	5375	1241	1015				
NOx Emissions (g/hr)	563	430			266	1046	241	197				
VOC Emissions (g/hr)	671	512			317	1246	288	235				
Dilemma Vehicles (#)	0	0			0	0	0	0				
Queue Length 50th (ft)	~724	672			576	~1545	~475	~413				
Queue Length 95th (ft)	#953	805			686	#1816	#694	#632				
Internal Link Dist (ft)		570			164			755			814	
Turn Bay Length (ft)												
Base Capacity (vph)	381	2559			1688	1043	362	358				
Starvation Cap Reductn	0	209			0	0	0	0				
Spillback Cap Reductn	0	0			0	0	0	0				
Storage Cap Reductn	0	0			0	0	0	0				
Reduced v/c Ratio	1.59	0.95			0.88	1.48	1.21	1.14				

Movement	NBT	NBR	SBL	SBT	SWL	SWR
Lane Configurations	↑↑↱		↰	↑↑	↰	↱
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Volume (veh/h)	2657	12	29	2189	29	76
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	2888	13	32	2379	32	83
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None		
Median storage veh)						
Upstream signal (ft)				244		
pX, platoon unblocked					0.29	
vC, conflicting volume			2901		4147	1451
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			2901		9390	1451
tC, single (s)			4.1		6.8	6.9
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			75		0	31
cM capacity (veh/h)			124		0	120

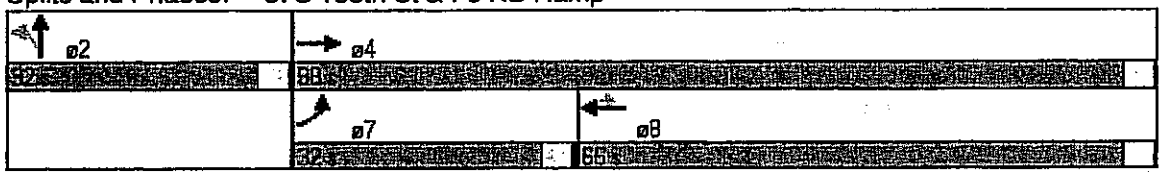
Direction, Lane #	NB 1	NB 2	SB 1	SB 2	SB 3	SW 1	SW 2
Volume Total	1925	976	32	1190	1190	32	83
Volume Left	0	0	32	0	0	32	0
Volume Right	0	13	0	0	0	0	83
cSH	1700	1700	124	1700	1700	0	120
Volume to Capacity	1.13	0.57	0.25	0.70	0.70	Err	0.69
Queue Length 95th (ft)	0	0	24	0	0	Err	92
Control Delay (s)	0.0	0.0	43.7	0.0	0.0	Err	84.0
Lane LOS			E			F	F
Approach Delay (s)	0.0		0.6			2822.5	
Approach LOS						F	

Intersection Summary			
Average Delay	59.6		
Intersection Capacity Utilization	85.2%	ICU Level of Service	E
Analysis Period (min)	15		

Intersection Summary

Area Type: Other
Cycle Length: 130
Actuated Cycle Length: 130
Offset: 0 (0%), Referenced to phase 2:NBTL and 6:, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.59
Intersection Signal Delay: 117.9 Intersection LOS: F
Intersection Capacity Utilization 150.9% ICU Level of Service H
Analysis Period (min) 15
~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 3: S 188th St & I-5 NB Ramp

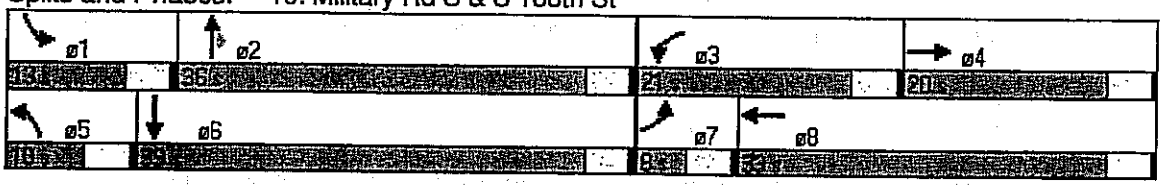


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Turning Speed (mph)	15		9	15		9	15		9	15		9
Lane Util. Factor	1.00	1.00	1.00	0.97	1.00	1.00	1.00	0.95	1.00	1.00	0.91	0.91
Frt		0.992			0.965				0.850		0.996	
Flt Protected	0.950			0.950			0.950			0.950		
Satd. Flow (prot)	1770	1848	0	3433	1798	0	1770	3539	1583	1770	5065	0
Flt Permitted	0.950			0.950			0.950			0.950		
Satd. Flow (perm)	1770	1848	0	3433	1798	0	1770	3539	1583	1770	5065	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		3			18				458		6	
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		1070			798			306			408	
Travel Time (s)		24.3			18.1			7.0			9.3	
Volume (vph)	23	194	11	574	424	130	110	976	421	156	1769	52
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	25	211	12	624	461	141	120	1061	458	170	1923	57
Lane Group Flow (vph)	25	223	0	624	602	0	120	1061	458	170	1980	0
Turn Type	Prot			Prot			Prot		Perm	Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases									2			
Total Split (s)	8.0	20.0	0.0	21.0	33.0	0.0	10.0	36.0	36.0	13.0	39.0	0.0
Act Effct Green (s)	4.0	16.0		17.0	29.0		6.0	32.0	32.0	9.0	35.0	
Actuated g/C Ratio	0.04	0.18		0.19	0.32		0.07	0.36	0.36	0.10	0.39	
v/c Ratio	0.32	0.67		0.96	1.02		1.02	0.84	0.53	0.96	1.00	
Control Delay	52.4	45.5		64.9	72.6		132.4	34.3	4.7	101.2	49.5	
Queue Delay	0.0	1.1		6.5	0.0		0.0	0.0	0.0	0.0	0.7	
Total Delay	52.4	46.5		71.5	72.6		132.4	34.3	4.7	101.2	50.1	
LOS	D	D		E	E		F	C	A	F	D	
Approach Delay		47.1			72.0			33.2			54.2	
Approach LOS		D			E			C			D	
Stops (vph)	25	185		508	459		88	854	39	130	1606	
Fuel Used(gal)	1	5		14	14		4	19	4	4	33	
CO Emissions (g/hr)	40	324		976	991		299	1315	262	309	2308	
NOx Emissions (g/hr)	8	63		190	193		58	256	51	60	449	
VOC Emissions (g/hr)	9	75		226	230		69	305	61	72	535	
Dilemma Vehicles (#)	0	0		0	0		0	0	0	0	0	
Queue Length 50th (ft)	14	118		182	~344		~71	288	0	98	~406	
Queue Length 95th (ft)	40	#207		#290	#565		#182	#373	62	#223	#532	
Internal Link Dist (ft)		990			718			226			328	
Turn Bay Length (ft)												
Base Capacity (vph)	79	331		648	592		118	1258	858	177	1973	
Starvation Cap Reductn	0	0		0	0		0	0	0	0	0	
Spillback Cap Reductn	0	22		22	0		0	0	0	0	5	
Storage Cap Reductn	0	0		0	0		0	0	0	0	0	
Reduced v/c Ratio	0.32	0.72		1.00	1.02		1.02	0.84	0.53	0.96	1.01	

Intersection Summary

Area Type: Other
Cycle Length: 90
Actuated Cycle Length: 90
Offset: 0 (0%), Referenced to phase 2:NBT and 6:SBT, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.02
Intersection Signal Delay: 51.5 Intersection LOS: D
Intersection Capacity Utilization 88.3% ICU Level of Service E
Analysis Period (min) 15
~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 10: Military Rd S & S 188th St



LEVEL OF SERVICE CONCEPT

Because intersection capacity and traffic flow performance, or "level of service", are prime factors in the process of developing and evaluating alternatives, a brief description is presented here for the benefit of the lay reader.

The ratio of existing traffic volume to available capacity provides a measure of the intensity of traffic loading relative to the ability of the street intersection to accommodate the traffic. The number of lanes, presence of turn lanes, type of traffic control, signal phasing, etc., are important factors in determining capacity. As the volume-to-capacity (v/c) ratio approaches a value of 1.0 at signalized intersections, extreme congestion sets in, with long backups and several complete changes of the signal cycles occuring before a motorist can proceed. Motorists at stop-sign controlled intersection approaches face extremely long delays when the v/c ratio approaches 1.0. As traffic queues lengthen, this congestion can also impede access to and from upstream abutting property.

The term "level of service" is used to describe traffic flow at intersections. For signalized intersections, the level of service is based on control delay per vehicle (see **table A-1**). Control delay is a measure of all the delay contributable to traffic control measures, such as a traffic signal. Control delay includes initial acceleration delay, queue move-up time, stopped delay, and final acceleration delay.

Table A-1
Level of Service and Volume/Capacity Ratio Relationships for Signalized Intersections

Level of Service	General Description	Control Delay (seconds/vehicle)[1]	Intersection V/C Ratio[2]
A	Free flow	≤ 10.0	≤ 0.60
B	Stable flow (slight delays)	10.1 to 20.0	0.61 to 0.70
C	Stable flow (acceptable delays)	20.1 to 35.0	0.71 to 0.80
D	Approaching unstable flow (tolerable delay - occasionally wait through more than one signal cycle before proceeding)	35.1 to 55.0	0.81 to 0.90
E	Unstable flow (intolerable delay, intersection operating at capacity)	55.1 to 80.0	0.91 to 1.00
F	Forced flow (jammed)	> 80.0	> 1.00

1. For operational analysis method which requires detailed geometric, traffic, and signal information usually used for existing conditions analysis.
2. For planning-level analysis method. Planning-level analysis is used when there is less certainty in the input when default values are typically relied upon and future traffic forecasts are used.

Source: "Highway Capacity Manual", Transportation Research Board, 2000; and "Interim Materials on Highway Capacity", *Circular 212*, Transportation Research Board, 1980.

Level of service A is a condition of unimpeded flow, while level of service C is often used in the design of new urban streets as the lowest acceptable level for peak periods. Congestion begins to occur at level of service D (v/c from 0.81 to 0.90). Because of funding and/or environmental constraints for improvements, this level of service is being used by more and more cities as an adequate level, particularly for improvements to congested existing facilities. Increasingly unstable traffic flow with excessive delay and congestion occurs as level of service E (capacity) is approached (v/c = 0.91 to 1.00). For v/c > 1.00, level of service F (forced flow) is obtained, and the intersection is overloaded or is jammed due to traffic backups from overloaded downstream intersections.

It should be noted that equal v/c ratios at several locations do not necessarily indicate equal overall performance of intersections. One intersection may experience a high v/c ratio for a considerable period of the day while at another intersection the peak period lasts a short time. In addition, a low level of service is more tolerable at a low-volume intersection than a high-volume location.

The general level of service concept also holds for stop-sign controlled intersections, although the capacity of the stop-sign controlled approaches is less than that of the signalized intersection approach. **Table A-2** shows the level of service criteria for unsignalized intersections.

Table A-2
Level of Service Criteria for Unsignalized Intersections

Control Delay (d)[1]	Level of Service
$d \leq 10$	A
$10 < d \leq 15$	B
$15 < d \leq 25$	C
$25 < d \leq 35$	D
$35 < d \leq 50$	E
$d > 50$	F[2]

1. Control delay is measured in seconds per vehicle.
2. For level of service F, when demand volume exceeds the capacity of the lane, extreme delays will be encountered with queuing which may cause severe congestion affecting other traffic movements in the intersection. This condition usually warrants improvements to the intersection.

Source: "Highway Capacity Manual", Transportation Research Board, 2000.

Capacity analysis for two-way stop-sign controlled intersections is based on the assumption that major street traffic is not affected by the minor street movements, and that left-turns from the major streets to the minor streets are influenced only by opposing major street through flow. Therefore, the level of service calculated for two-way stop intersections is based on delay experienced by only the minor street movements and the major street left-turn movement.

MEMORANDUM

To:	Karl Hufnagel	Date:	May 12, 2004
From:	Kurt Gahnberg	TG:	02250.00
cc:			
Subject:	Bow Lake Transfer Station – Summary of Preliminary Transportation Assessment		

This memorandum briefly documents the results of the preliminary traffic assessment of access enhancement options for the existing Bow Lake Transfer Station, that were presented to KCSWD staff at a meeting March 5, 2004. It includes:

- Background
- Comparison of Alternatives
- Summary

Background

Options to enhance access at the Bow Lake transfer station have been under investigation by the RW Beck team since summer 2003. Current site access is hampered by the close proximity of the transfer station access road to the existing ramp terminals at the S 188th Street/I-5 Interchange. This close spacing results in traffic queue interference with access traffic, especially slower moving transfer trucks. In addition, safety is a concern for traffic entering S 188th Street from the site, and for left turning traffic from S 188th Street into the site. The Bow Lake Transfer Station remains an important component of King County solid waste management strategy far into the future.

Range of Options Considered

A wide range of access enhancement options have been considered by the team, ranging from minor channelization modifications, to traffic signalization of the site entrance intersection with S. 188th Street, to significantly more-expensive roadway and ramp revisions requiring coordination with Washington State Department of Transportation (WSDOT) to effectively implement. None of the lowest cost options provided any substantial benefit to improve existing traffic operations, or adequately accommodate future traffic volume levels associated with anticipated growth.

The only conceptual option that was determined to provide adequate traffic operational benefit was to combine the I-5 northbound ramps with the site access road, as well as S. 188th Street and Orilla Road approaches, into what is commonly referred to as a single point interchange. The most recent analysis has focused on this

core option, with further examination of permutations of this option. The most current evaluation focuses on the following options:

- **Single Point Interchange (SPI)** – Basic design which brings the west leg of S. 188th Street into a single intersection with the I-5 northbound ramps, the east approach from Orillia Road, together with the access to the Bow Lake Transfer Station.
- **SPI With Right Turn Bypass** – Removes right turning traffic from theI-5 northbound off ramp from the intersection, and accommodates them in a separate turning ramp to eastbound Orillia Road.
- **SPI With Right turn Bypass and Orillia Road/I-5 Northbound Flyover** – This option removes the westbound Orillia Road destined for northbound for northbound I-5 from the intersection operation by accommodating them in a flyover ramp.

The basic option (SPI) improves operation over existing conditions by accommodating all traffic at a single point, allowing signalized control of the Bow Lake Transfer Station access, and doing so in a way that increases intersection spacing between the northbound and southbound I-5 ramp terminals. Implementation of any of the options above will require the close coordination between WSDOT and King County, as well as the neighboring city of Tukwila.

The analysis considered the following traffic characteristics:

- **Background Traffic Growth** – A long range traffic horizon was considered. Traffic forecast factors were acquired from King County, and included the Green River Valley and Highline subareas, which are forecast to grow at approximately 23 and 5 percent, respectively. Application of these two data points resulted in consideration of a worst case and probable traffic forecast for 2023 conditions.
- **AM and PM Peak Hour Traffic Analysis** – Both AM and PM peak hour traffic conditions were examined.
- **Intersection Level of Service** – Traditional intersection analysis was conducted to assess future traffic delays and compare the affect of the identified options on the traffic capacity of the I-5/S 188th Street/Orillia Road freeway ramps and site access driveway.
- **Traffic Queuing** – The close spacing of the S. 188th Street ramp terminals with northbound and southbound I-5, together with the Bow Lake Transfer Station access road, requires consideration of the relative effect of traffic queues occurring between intersections to understand the operational viability of future options.

Comparison of Alternatives

The following summarizes the preliminary traffic assessment of the single point interchange options considered. It describes intersection Level of Service (LOS), traffic queuing, and other factors relevant to comparing the operational options for the following

Intersection Level of Service

Attachment 1 (LOS Handout from Meeting) summarizes the LOS analysis for each of the alternatives for 2023 conditions. Two scenarios were developed. First, a worst case assumption that all traffic would grow at a rate consistent with the Green river Valley growth factor (23%) was evaluated. Second, a hybrid growth rate that applied the Green River Valley rate only to the east leg of the intersection (Orillia Road approach) while applying the lower 5 percent growth rate to the other primary approaches. The latter reflects a more-reasonable approach, in that the high level of existing traffic associated with the I-5 off ramps, as well as S. 188th Street to the west, are likely to grow at a substantially lower rate than the higher growth Green River Valley. They are both presented to reflect sensitivity analysis.

The analysis summarized in Attachment 1 generally shows that the PM peak hour will continue to experience higher levels of traffic congestion than occur during the AM peak hour. It also shows that the blended growth rate results in more-feasible levels of service associated with each of the options. During the PM peak hour, resulting traffic operations would be similar for both the basic and basic with right turn bypass case, LOS "E". When the effect of the traffic removed as a result of the flyover ramp is added, operations would improve by a complete level of service, resulting in LOS "D", and about 15 seconds less delay than described for the other options in the PM peak hour.

In summary, traffic growth to 2023 will contribute to further substantial decline in overall street system and access performance surrounding the Bow Lake Transfer Station. The single point interchange will improve operations and safety compared to doing nothing, but alone would result in continued significant delays. Addition of the right turn ramp bypass alone would improve AM peak hour operations, but have a minimal impact on relieving PM peak hour congestion. However, with the addition of the flyover ramp to eliminate westbound traffic from Orillia Road to northbound I-5 from the intersection, a significant operational improvement could occur.

Traffic Queuing

Traffic queuing associated with the 2023 conditions were also reviewed. All options would provide adequate queuing capacity to accommodate anticipated traffic demand, with the exception of the eastbound approach to the intersection on S. 188th Street. This movement currently has traffic queues that exceed the available capacity, and will continue to do so in the future under any scenario. This queuing, while significant, would not directly affect the access viability for the single point

interchange in serving the Bow Lake Transfer Station. However, fully understanding the interaction between traffic signals and intersections in the interchange area will require ongoing evaluation, and may receive additional scrutiny in light of any specific development or transportation improvement proposal.

Summary

KCSWD is considering the further development of the Bow Lake Transfer Station to support the County's solid waste management strategy. Current site access is problematic in that heavy through traffic volumes on S. 188th Street, together with turning movements associated with the closely spaced I-5 ramp terminals, result in substantial access delays, and safety concerns for traffic turning into and out of the Bow Lake site. Of the range of improvements considered, the modification of the I-5 northbound ramps to realign the landing point to provide a 5-way single intersection that combines the Bow Lake access road provides improved safety and operations. However, in order to provide operating conditions of LOS "D" or better during both AM and PM peak hour conditions, it is necessary to consider further substantial investment in the roadway infrastructure, including the development of a single point interchange with the I-5 northbound ramp terminal and the Bow Lake transfer station access, incorporation of a separate right turn access from the northbound off-ramp to eastbound Orillia Road, and the development of a flyover structure to intercept westbound Orillia Road traffic destined for northbound I-5.

Based on this analysis, further investigation of the feasibility and cost of construction associated with this concept should be undertaken.

Attachment

M\02\02150 Bow Lake TS\Summary Memo – Traffic Assessment.doc

Bow Lake Transfer Station
Level of Service

PM Peak Hour LOS – Single Point NB Ramp Intersection

Intersection Options	2023 with Green Valley Growth			2023 with Highline/Green Valley Growth		
	LOS[1]	Delay[2]	V/C[3]	LOS	Delay	V/C
Basic Design	F	88.4	1.08	E	61.3	1.01
w/ right by-pass	F	88.3	1.08	E	60.8	1.00
w/ right by-pass and flyover[4]	E	76.9	1.02	D	44.5	0.91

1. Level of service.
2. Average delay in seconds per vehicle.
3. Volume-to-capacity ratio.
4. The flyover alternative was also evaluated with the existing intersection geometry. The results indicated overall operations were similar to or worse than the option with the flyover added to the single-point intersection and resulting traffic queues between existing intersections were unacceptable.

AM Peak Hour LOS – Single Point NB Ramp Intersection

Intersection Options	2023 with Green Valley Growth			2023 with Highline/Green Valley Growth		
	LOS	Delay	V/C	LOS	Delay	V/C
Basic Design	E	76.6	1.04	E	61.4	0.98
w/ right by-pass	E	56.8	0.98	D	45.8	0.93
w/ right by-pass and flyover[4]	D	37.7	0.87	C	26.4	0.78

1. Level of service.
2. Average delay in seconds per vehicle.
3. Volume-to-capacity ratio.
4. The flyover alternative was also evaluated with the existing intersection geometry. The results indicated overall operations were similar to or worse than the option with the flyover added to the single-point intersection and resulting traffic queues between existing intersections were unacceptable.